

CDE POLICY BRIEF



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A burning challenge: Making biomass cooking fuels sustainable in East Africa

Carbon constraints have further complicated the quest to power the developing world. Notions of an “energy ladder” – with fossil fuels at the top – no longer make clear sense. Steps up in combustive power could mean steps down in the effort against climate change. In East Africa, as in much of the global South, people still rely on time-tested, “bottom-rung” energy sources like wood, charcoal, and farm by-products.¹ These and other biomass fuels will remain vital in the region for years to come – especially for cooking – due to population growth and cost hurdles.² But related risks to people’s health and the environment must be reduced.³ With proper resource management and improved cookstoves, use of biomass fuels like wood and biogas could be made more sustainable, while helping meet the cooking-energy needs of East Africa’s rising population through 2030.⁴ Meanwhile, work can proceed on longer-term solutions like clean electricity from renewables.

Cooking-energy challenges

Energy is vital to development. Writ large, it enables industry, building, transport, trade, communication, etc. In people’s homes, it enables essentials like cooking, lighting, and heating. Lack of access to safe, affordable energy is one of the biggest obstacles to human well-being in

poor countries. Sustainable Development Goal 7 highlights the challenge.⁵ Across the developing world, households continue to rely on burning solid biomass like wood for energy – particularly to cook. In East Africa, about 90% of rural and low-income urban families still cook with firewood or charcoal.⁶

KEY MESSAGES

- Biomass, especially wood, will remain a vital source of cooking energy in East Africa for some time. Making biomass use more sustainable requires policies that safeguard finite resources (mainly forests), enable regrowth, shrink carbon footprints, strengthen local economies, and protect people from health risks (e.g. smoke).
- Charcoal is a dominant local biomass fuel, but it is not efficient. Too much energy is lost in the charcoal-making process, also magnifying its carbon footprint. Alternative biomass fuels include sustainably managed wood, biogas, farm residues, and jatropha. These fuels can be combined based on local availability to help cover people’s cooking-energy needs.
- Improved cookstoves (e.g. micro-gasifiers) must be used to optimize biomass use and better protect people’s health. But good ventilation of cooking areas remains crucial.
- Several types of land use are suited to generate biomass fuels, in particular agroforestry, small-scale mixed farming, and sustainable forest plantations.



The research featured here is focused on East Africa.

Box 1. The Prospect of Biomass Energy (PRoBE) project in East Africa

Insights described here stem from research carried out between 2013 and 2017 in Kitui County, Kenya, and Kilimanjaro Region, Tanzania, as part of the PRoBE project. CDE researchers and partners sought to identify the potentials and limitations of improved, pro-poor biomass energy strategies. Researchers modelled different scenarios of biomass energy production and use, looking for sustainable ways of meeting the projected growth of cooking-energy demand in East Africa through 2030. The results highlight the advantages of using a *diverse mix* of biomass fuels, optimizing and combining potentials in different settings to cover national/regional energy needs. The PRoBE project was conducted within the Swiss Programme for Research on Global Issues for Development (r4d programme; project no. IZ01Z0_146875), funded by the Swiss Agency for Development and Cooperation (SDC) and the Swiss National Science Foundation (SNSF). In addition to CDE, project partners included the Centre for Training and Integrated Research in ASAL Development (CETRAD), Kenya; Quantis, Switzerland; Practical Action Eastern Africa, headquartered in the UK; and the Tanzania Traditional Energy Development Organization (TaTEDO), Tanzania.



M2 micro-gasifier stove of the Wisdom Innovation Company in Kenya during a water-boiling test conducted at the University of Nairobi in 2016. Photo: S. Willi

But this reliance on burning biomass can have serious consequences. Firstly, it currently constitutes a global public health crisis. The World Health Organization (WHO) estimates that 4.3 million people die every year from household air pollution – i.e. particulate matter and carbon monoxide (CO) – produced, in particular, by cooking with solid fuels.⁷ That is more people than die yearly from HIV/AIDS, malaria, and tuberculosis combined. In East Africa, respiratory diseases caused by indoor air pollution account for about 14,300 deaths in Kenya and 18,000 deaths in Tanzania each year, according to recent WHO figures.⁸

Secondly, it can take a major toll on the natural environment. If not sustainably managed, use of woody biomass for fuel and charcoal can drive forest degradation and loss. And if forests are not replanted and regrown to absorb the CO₂ released during burning, the cycle of overuse adds to the threat of climate change.⁹

Finding solutions

Despite these risks, charcoal and wood still provide indispensable cooking energy to the poor in East Africa and elsewhere, as well as jobs.¹⁰ This makes it critical to identify how use of these or other biomass fuels can be made more sustainable in the short to medium term.

Doing so requires answering key questions like: *What biomass can be regionally produced now and in the future? Can supplies furnish enough cooking energy for rising local populations? And is it possible to reduce risks to people's health and the environment?* For most places, the answers will likely point to a mix of biomass energy sources. In East Africa, research by CDE and its partners (see Box 1) highlights four biomass fuels as having sustainable cooking-energy potential, based on environmental, economic, and health criteria.

Promising biomass fuels

Sustainably managed wood has major untapped potential in East Africa, provided long-term forest regrowth is strictly ensured (e.g. in 40- to 50-year cycles).¹¹ The regional supply (e.g. forests, deadwood) and local market prospects (e.g. rural-urban trade) of fuelwood are good.¹² Crucially, use of raw wood to cook can be much more *energy-efficient* than use of charcoal, which dominates in many (mainly urban) areas: In charcoal production (i.e. kiln firing), half the energy stored in wood is lost, on average.¹³ Burning wood directly in an improved cookstove delivers more of that stored energy to end-users. This reduces pressure on forests because less wood is needed to produce the same or more cooking energy. CDE researchers estimated that if just *half* the wood used to make charcoal in the study sites were used directly as (chipped) fuelwood, it would be possible to

triple the number of meals cooked without significantly increasing the overall carbon footprint (see Figure 1).

Biogas produced from animal (e.g. cow) dung also shows strong potential as a cooking fuel in parts of East Africa where livestock keeping is common. However, the animals should be centrally fed indoors, not put to pasture (i.e. zero graze), so their dung can be easily collected. Also, sufficient quantities of water are needed to mix with the dung in *bi-digesters* that produce the gas. Study results from Kilimanjaro Region, Tanzania, point to biogas potential equivalent to over 70 million cooked meals annually – about one-third of the charcoal potential in the same region, which is substantial.¹⁴ Biogas production has the advantage of turning a free by-product (dung) into energy. Some livestock-keeping families or communities can use biogas to cover their entire energy needs.

Farm residues such as maize cobs and rice husks, pressed into briquettes, also show modest potential as part of a regional energy mix. They can be used by farming households as a supplement to other biomass fuels like wood. Similar to biogas, farm residues are a by-product that may be turned into energy at little cost, aiding energy self-sufficiency.

Jatropha seeds derived from hedges (“living fences”) around farm plots also have modest fuel potential.¹⁵

Improved cookstoves

Crucially, *improved cookstoves* must be used to realize the potential of these alternative fuels and especially to better protect people's health. This is no small matter because stoves can be relatively expensive and some studies indicate weak uptake and improper use of improved stoves.¹⁶ Picking the right stove depends on the biomass fuels used (e.g. wood or non-wood), upfront costs versus long-term benefits (e.g. fuel savings), maintenance availability, etc. (see Box 2).

Micro-gasifier stoves show particular promise (see photo, left). They are capable of burning various fuels in different forms, whether wood (e.g. cut, pelletized, or sawdust briquettes), crop residues (briquettes), or jatropha (seeds or briquettes). They are efficient, cutting fuel use by up to 50% compared with traditional three-stones fireplaces.¹⁷ They can also reduce risky indoor emissions: Our independent lab tests¹⁸ confirmed earlier findings¹⁹ showing a significant reduction in particulate matter (30–80% with wood) compared with traditional stoves, provided the micro-gasifier is used correctly (e.g. proper filling, good airflow).

Improved wood stoves are another, cheaper option. They have decent *thermal efficiency* (e.g. 30%), delivering more heat to the cooking pot than traditional three-stones fireplaces (12.5%). But they are not as efficient as micro-gasifiers and still produce too much indoor air pollution.

Biogas stoves are required in the case of biogas. Installation of a full system including the biodigester involves high upfront costs (USD 500–1,000).²⁰ But once in place a system can last around 15 years, delivering clean-burning gas to stoves with high thermal efficiency (55%) at low cost.²¹

More room for improvement

Each of these fuel/stove combinations has its weaknesses. The wood-burning stoves still produce too much pollution – even the best micro-gasifier we tested would expose users to twice the WHO 24-hour limit for indoor concentration of airborne particulate matter (PM 2.5). Ventilation of cooking areas thus remains crucial. The biogas systems are initially expensive, need improvements to prevent methane (CH₄) leaks, and only work in live-stock-keeping areas. Finally, farm residues and jatropha can only meet a small fraction of cooking-energy needs in farming areas.

But all have smaller carbon footprints than the current use of charcoal/fuelwood in East Africa. They also reduce pressure on natural resources. And they can deliver these benefits while helping meet the rising demand for cooking energy in Kenya and Tanzania through 2030 (see Figure 1).

Supportive land uses and sector development

Importantly, the success of these alternative biomass fuels depends on proper land use and sector development. The most promising land uses are those that have dense supply potentials – i.e. high productivity per square kilometre – and cover wide geographic areas in East Africa.²² Based on these criteria, *agroforestry* and *small-scale mixed farming* appear to be particularly suitable. They can produce a diverse mix of biomass fuels, including sustainably managed wood, biogas, farm residues, and jatropha. In addition, sustainable *forest plantations* could provide more fuelwood if their area were increased and more wood were allocated for fuel use. Finally, *large-scale farming* could also supply more biomass fuels, e.g. crop-residue briquettes, if existing farms tapped their potential.

Finally, it is important to distinguish between biomass fuels suited to *self-provision* and local *marketing and trade* when considering sector development. Sustainably managed wood has the biggest supply potential – 87% in our Kitui, Kenya, case study – and is suitable for marketing and local rural–urban trade, in addition to its dominant use for energy self-provision. Jobs in processing (e.g. chip-ping) and transporting wood could replace similar charcoal-sector jobs. By contrast, small-scale biogas and farm-residue briquettes are more suited to energy self-provision at the household or community level. Marketing them currently appears uneconomical or unfeasible. Notably, however, there remains good market potential for the sale and support (e.g. maintenance) of improved biomass stoves of virtually all types.

Box 2. Meeting people's needs and preferences

People's reasons for using "unsustainable" or "unhealthy" cooking fuels/stoves are not mysterious, but must be kept in mind when identifying and promoting alternatives. Families in rural areas cook with a basic three-stones fireplace and fuelwood because they are easily accessible, flexible, and essentially free.²³ The main "cost" is that of the (significant) time it takes family members – especially women and children – to collect wood from nearby forests, light a fire, etc. Urban dwellers, by contrast, generally lack forest access and cook with charcoal instead because it is consistently available at local markets, dense in energy, emits less smoke, and is seen as more "modern" than raw wood. At the same time, these groups express willingness to switch to alternative cooking fuels/stoves.²⁴ For alternatives like sustainably managed wood or biogas to succeed, however, they must be made similarly accessible, affordable, user-friendly, and even "desirable". In one win–win scenario, environmentally unsustainable charcoal-production chains would be transformed into sustainable local wood-production chains, preserving or creating jobs in rural areas while delivering fuelwood to nearby urban areas. Finally, for people to realize the benefits of improved stoves like micro-gasifiers, they require instruction in proper use of the stoves and long-term maintenance support.

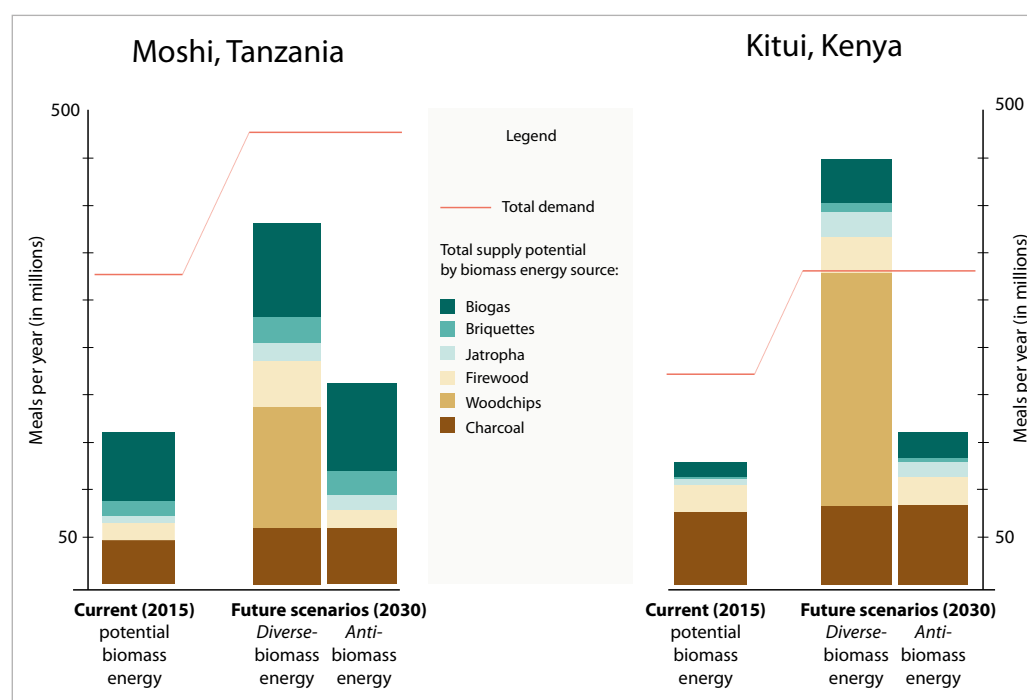


Figure 1. Demand for cooking energy will rise by about 40% in our study sites by 2030. This graphic shows the approximate number of meals (in millions) that can be cooked with local biomass fuels now and in the future (vertical bars), compared with estimated demand (red line). The projections for 2030 show two different policy scenarios: *Anti-biomass* assumes lack of promotion of sustainable biomass cooking energy; *Diverse-biomass* assumes policy support for a better biomass energy mix, including more sustainable use of wood, biogas, and improved cookstoves. (Data, R. Bär 2018; graphic, C. Bader 2018)

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Policy implications of research

Acknowledge that biomass will remain vital for cooking energy through 2030

Barring rapid installation of high-tech “green” energy infrastructure, biomass like wood and farm residues will remain chief sources of *renewable* cooking energy in East Africa until at least 2030. Population growth, cost hurdles, and access obstacles mean that biomass fuels will be needed to help cover cooking-energy needs. But their use must be made safer and more sustainable.

Support sustainable local production and use of biomass fuels – ideally a mix

Based on local supply potentials and scope for sustainability, a *mix* of four biomass cooking fuels shows particular promise in East Africa: wood, biogas (e.g. from dung), farm residues, and jatropha. Land uses like agroforestry, small-scale mixed farming, and sustainable forest plantations are ideal to produce these fuels. For woodfuels, tree replanting and regrowth must be strictly ensured. Gradually, an improved local woodfuel sector could partly replace the less energy-efficient charcoal sector in some (e.g. urban) areas. Other fuels (e.g. small-scale biogas) are more suited to self-provision. In every case, keeping use within sustainable limits is crucial – including air quality.

Promote use of the safest, cleanest, most efficient biomass cookstoves possible

East Africans should not have to sacrifice their personal health due to global carbon constraints. If they avoid cooking with fossil fuels – e.g. liquefied petroleum gas (LPG) – to protect our climate, then every effort must be made to cut their exposure to unsafe biomass air pollution. Use of improved cookstoves is critical. Currently, micro-gasifiers perform best among (non-charcoal) solid biomass stoves. But they still fail to satisfy WHO air-quality guidelines. Biogas systems are better, rivalling even LPG. Policymakers should support distribution, use, quality control, and ongoing improvement of the safest, cleanest, most efficient biomass cookstoves possible.

Maintain longer-term goal of safe renewable energy for all

Beyond 2030, the energy goal of East Africa should be the same as everywhere else – i.e. providing everyone with safe, low-carbon energy not only for cooking, but also for lighting, refrigeration, transport, etc. Biomass fuels like wood and biogas may just be steppingstones to better renewables. Or – with improvements – they might remain part of a sustainable future energy mix, playing a role alongside “top-rung” energy sources like solar, wind, water, geothermal, etc.

Suggested further reading

Bär R, Ehrensperger A. 2018. Accounting for the Boundary Problem at Subnational Level: The Supply–Demand Balance of Biomass Cooking Fuels in Kitui County, Kenya. *Resources* 7(11). <http://bit.ly/2GTWJfv>

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